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Influence of limestone content, fineness, and composition on the properties and microstructure of alkali-activated slag cement

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ABSTRACT

The influence of the fineness, concentration, and chemico-mineralogical composition of limestone on the workability, reaction kinetics, compressive strength, microstructure, and binder gel characteristics of sodium carbonate–based waste-activated waste slag cement pastes was investigated in this work. Alkali-activated slag cements incorporated with limestone, containing 33–100% of calcite, at a content of up to 60% with a 28-day compressive strength of 26.2–48.8 MPa were proposed. The main reaction products of hardened alkali-activated cement pastes and those incorporated with limestone are C–S–H, $CaCO_3$, $Na_2Ca(CO_3)_2 \cdot 5H_2O$, and Na_2CaSiO_4. "Physically active" limestone does not chemically react with the binder gel but it can improve the physical structure. The higher packing density of mixed cement, without an increase in the water demand, the satisfactory binding strength of limestone with the binder gel lead to the improvement in the physical structure and compressive strength of alkali-activated slag paste.

1. Introduction

Alternative or non-traditional cements form a large group of binders, differing significantly from Portland cement and from each other by the composition and type of raw materials, nature of hardening products, mechanism of hardened cement paste formation, and the research experience, adoption, and application of each type of cement [1]. Some types of alternative binders also termed new cements for the 21st century, new cementitious matrixes, combining higher, in comparison with PC, 'ecological compatibility' and some technical characteristics are proving to be increasingly promising in terms of partial replacement of ordinary Portland cement (OPC) in the present climate of 'sustainable development' [1,2]. The non-clinker non-fired alkali-activated cements (AACs) belong to this category of cement [3–5]. Such materials usually consist of two components: an aluminosilicate precursor and an alkaline activator, with a variety of industrial by-products and aluminosilicate solids having been used as raw materials. At the present stage of development of AACs, ground granulated blast furnace slag (GGBFS) and fly ash are accepted as attractive precursors for large-scale industrial production of AACs [6]. However, fly ash and metallurgical slag are not available everywhere nor has the supply chain for their distribution been established in local markets; this is because the supply chain has an interdependence on the existence of a ready market [4]. According to past studies, a wide range of natural materials and by-products is suitable for the replacement of GGBFS, which also has valuable technical advantages and economic benefits [7–10]. The cost and environment footprint of the alkali activator also holds importance in the further development of alkali-activated slag cement (AASC), which is why the application of widely accessible mineral admixtures that can effectively substitute for GGBFS in AASC activated by appropriate alkali components, including alkali-containing wastes, is of scientific and practical interest.

One of the most popular mineral admixtures for OPC is limestone (LS) owing to its abundance and chemical-mineralogical composition [11,12]. Portland–LS cements are the most widely used cements in Europe. Two classes exist in EN 197-1 designated as CEM II/A-L and CEM II/B-L, in which the maximum contents of limestone are 20 and 35%, respectively. Several studies in the past

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